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(54) Title: NEMATICIDAL COMPOSITIONS CONTAINING PLANT ESSENTIAL OILS AND MIXTURES OR BLENDS THEREOF

(57) Abstract

Nematicidal compositions containing plant essential oils and mixtures or blends thereof. In addition, the present invention is directed to a method for controlling nematodes by applying a pesticidally-effective amount of the above nematicidal compositions to a locus where nematode control is desired.

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NEMATICIDAL COMPOSITIONS CONTAINING PLANT ESSENTIAL OILS AND MIXTURES OR BLENDS THEREOF

FIELD OF THE INVENTION

The present invention relates, in general, to nematicidal compositions containing plant essential oils and mixtures or blends thereof. In one aspect, the present invention relates to nematicidal compositions containing certain plant essential oils. In another aspect, the present invention relates to nematicidal compositions containing synergistic blends of certain plant essential oils. In a further aspect, the present invention relates to a method for controlling nematodes by the application of pesticidally effective amounts of the nematicidal compositions containing certain plant essential oils and/or synergistic blends thereof to a locus where nematode control is desired.

BACKGROUND OF THE INVENTION

Nematodes are the most numerous multicellular animals on earth. Nematodes are small roundworms that thrive in virtually all environments throughout the world. A handful of soil may contain thousands of the microscopic worms, many of them parasites of insects, plants or animals.

Nematode control is essential for the efficient production of agricultural and horticultural crops, and nematode control has been the subject of extensive research and investigation for more than 200 years. Nematodes that parasitize plants are a significant constraint to crop production, causing an estimated $8 billion annual losses to U.S. growers and nearly $78 billion annual losses globally.

Management of plant and soil nematodes has acquired new urgency in recent years. No new nematicide has been developed since 1974 and over half of the nine principal nematicides have been removed from the market or are under review by various environmental groups or regulatory bodies. The extreme reliance on

conventional pesticides to control nematodes must be replaced by economically yet environmentally friendly programs. The widespread use of synthetic chemical pesticides, including nematicides, has caused detrimental environmental effects that are harmful to humans and other animals. For instance, the public has become concerned about the amount of residual chemicals that persist in food, ground water and the environment, and that are toxic, carcinogenic or otherwise incompatible to humans, domestic animals and/or fish. Due to the fact that nematicides are applied to the soil, they can easily reach streams, lakes, and reservoirs in water that runs off treated areas. Worker safety is also an issue when applying these chemicals. As an alternative, botanical nematicides are of great interest because they are natural nematicides, i.e., toxicants derived from plants that are safe to humans and the environment.

Accordingly, there is a great need for novel nematicidal compositions containing plant essential oils and synergistic mixtures thereof. In addition, there is a need for methods for using same that address the problems described above, i.e., are safe to humans and the environment and relatively inexpensive to use in obtaining acceptable levels of nematode control.

SUMMARY OF THE INVENTION

A primary object of the present invention is to provide novel nematicidal compositions that contain certain plant essential oils.

Another object of the invention is to provide nematicidal compositions containing synergistic mixtures or blends of certain plant essential oils.

A still further object of the present invention is to provide a method for controlling nematodes by the application of the compositions of the present invention to a locus where such control is desired.

It is still another object of the present invention to provide novel nematicidal compositions that can be combined with conventional nematicides and other pesticides to provide equivalent control with reduced non-target toxicity.

It is still another object of the present invention to provide novel pesticidal compositions that can provide nematicidal and other pesticide (i.e. insecticidal) benefits in a single application.

It is a further object to provide a safe, non-toxic nematicidal composition and method that will not harm the environment.

It is still another object to provide a nematicidal composition and method that has a pleasant scent or no scent and that can be applied without burdensome safety precautions.

It is still another object to provide a nematicidal composition and method as described above which can be inexpensively produced or employed.

The above and other objects are accomplished by the present invention which is directed to nematicidal compositions containing certain plant essential oils and nematicidal compositions containing synergistic mixtures or blends of certain plant essential oils. In addition, the present invention is directed to a method for controlling nematodes by applying a pesticidally-effective amount of the above nematicidal compositions to a locus where nematode control is desired. The nematicides of the present invention may also be added to conventional nematicides to reduce non-target toxicity without sacrificing efficacy against nematodes.

Additional objects and attendant advantages of the present invention will be set forth, in part, in the description that follows, or may be learned from practicing or using the present invention. The objects and advantages may be realized and attained by means of the instrumentalities and combinations particularly recited in the appended claims. It is to be understood that the foregoing general description and the following detailed description are exemplary and explanatory only and are not to be viewed as being restrictive of the invention, as claimed.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

All patents, patent applications and literatures cited in this description are incorporated herein by reference in their entirety.

In one embodiment, the present invention provides a nematicidal composition comprising, in admixture with a suitable carrier and optionally with a suitable surface

active agent, a plant essential oil compound and derivatives thereof, including racemic mixtures, enantiomers, diastereomers, hydrates, salts, solvates and metabolites, etc.

Each plant essential oil or derivative thereof, comprises a monocyclic, carbocyclic ring structure having six-members and substituted by at least one oxygenated or hydroxyl functional moiety. Examples of plant essential oils encompassed within the present invention, include, but are not limited to, members selected from the group consisting of aldehyde C16 (pure), amyl cinnamic aldehyde, amyl salicylate, anisic aldehyde, benzyl alcohol, benzyl acetate, cinnamaldehyde, cinnamic alcohol, α-terpineol, carvacrol, carveol, citral, citronellal, citronellol, p-cymene, diethyl phthalate, dimethyl salicylate, dipropylene glycol, eucalyptol (cineole), eugenol, iso-eugenol, galaxolide, geraniol, guaiacol, ionone, d-limonene, menthol, methyl anthranilate, methyl ionone, methyl salicylate, α-phellandrene, pennyroyal oil perillaldehyde, 1- or 2-phenyl ethyl alcohol, 1- or 2-phenyl ethyl propionate, piperonal, piperonyl acetate, piperonyl alcohol, D-pulegone, terpinen-4-ol, terpinyl acetate, 4-tert butylcyclohexyl acetate, thyme oil, thymol, metabolites of trans-anethole, vanillin, ethyl vanillin, and the like. As these plant essential oil compounds are known and used for other uses, they may be prepared by a skilled artisan by employing known methods.

For example, a preferred embodiment relates to a nematicidal composition for agricultural and household (lawn & garden) use comprising a mixture of eugenol, α-terpineol, citronellal, thymol and trans-anethole.

It will be appreciated by the skilled artisan that the nematicidal compositions of the present invention unexpectedly exhibit excellent nematicidal activities without corresponding issues of toxicity to mankind and the environment. Without wishing to be bound by the following theories, it is believed that plant essential oils disrupt cell membranes in nematode tissue. Alternatively, plant essential oils inhibit transmission of vital neurotransmitters in the nervous system of nematodes. Alternatively, plant essential oils may act to dissolve cuticle in the exoskeleton of nematodes, causing dehydration and moisture loss. In any event, the net effect of the toxicity and action

of the inventive composition disclosed herein is heretofore unknown and unexpected.

Use of nematicidal compositions of the present invention generally results in fast, effective nematode control, particularly against plant parasites. As such, they are advantageously employed as nematicidal agents in uses such as, without limitation, agriculture, organic farming, lawn and garden, foliage application, solid treatment, soil incorporation application, seedling box treatment, stalk injection and planting treatment, turf and ornamentals, tree and shrub treatments, etc.

With respect to agriculture, the compositions are so chemically inert that they are compatible with substantially any other constituents of the spray schedule. They may also be used in combination with other pesticidally active compounds, and may themselves provide additional pesticidal benefits, including insecticidal and miticidal benefits.

The term "carrier" as used herein means an inert or fluid material, which may be inorganic or organic and of synthetic or natural origin, with which the active compound is mixed or formulated to facilitate its application to the plant, seed, soil or other object to be treated, or its storage, transport and/or handling. In general, any of the materials customarily employed in formulating pesticides, herbicides, nematicides or fungicides, are suitable. The inventive nematicidal compositions of the present invention may be employed alone or in the form of mixtures with such solid and/or liquid dispersible carrier vehicles and/or other known compatible active agents, especially plant protection agents, such as other pesticides, or acaricides, nematicides, fungicides, bactericides, rodenticides, herbicides, fertilizers, growth-regulating agents, etc., if desired, or in the form of particular dosage preparations for specific application made therefrom, such as solutions, emulsions, suspensions, powders, pastes, and granules which are thus ready for use. The nematicidal compositions of the present invention can be formulated or mixed with, if desired, conventional inert (i.e. plant compatible or nematicidally inert) pesticide diluents or extenders of the type usable in conventional pesticide formulations or compositions, e.g. conventional pesticide dispersible carrier vehicles such as gases, solutions, emulsions, suspensions, emulsifiable concentrates, spray powders, pastes, soluble

powders, dusting agents, granules, foams, pastes, tablets, aerosols, natural and synthetic materials impregnated with active compounds, microcapsules, coating compositions for use on seeds, and formulations used with burning equipment, such as fumigating cartridges, fumigating cans and fumigating coils, as well as ULV cold mist and warm mist formulations, etc.

Formulations containing the nematicidal compositions of the present invention may be prepared in any known manner, for instance by extending the nematicidal compositions with conventional pesticide dispersible liquid diluent carriers and/or dispersible solid carriers optionally with the use of carrier vehicle assistants, e.g. conventional pesticide surface-active agents, including emulsifying agents and/or dispersing agents, whereby, for example, in the case where water is used as diluent, organic solvents may be added as auxiliary solvents. Suitable liquid diluents or carriers include water, petroleum distillates, or other liquid carriers with or without surface active agents. The choice of dispersing and emulsifying agents and the amount employed is dictated by the nature of the composition and the ability of the agent to facilitate the dispersion of the nematicidal compositions of the present invention. Generally, it is desirable to use as little of the agent as is possible, consistent with the desired dispersion of the nematicidal compositions of the present invention in the spray so that rain does not re-emulsify the nematicidal compositions of the present invention after it is applied to the plant and wash it off the plant. Non-ionic, anionic, amphoteric, or cationic dispersing and emulsifying agents may be employed, for example, the condensation products of alkylene oxides with phenol and organic acids, alkyl aryl sulfonates, complex ether alcohols, quaternary ammonium compounds, and the like.

Liquid concentrates may be prepared by dissolving a composition of the present invention with a non-phytotoxic solvent and dispersing the nematicidal compositions of the present inventions in water with the acid of suitable surface active emulsifying and dispersing agents. Examples of conventional carrier vehicles for this purpose include, but are not limited to, aerosol propellants which are gaseous at normal temperatures and pressures, such as Freon; inert dispersible liquid diluent carriers, including inert organic solvents, such as aromatic hydrocarbons (e.g.

benzene, toluene, xylene, alkyl naphthalenes, etc.), halogenated especially chlorinated, aromatic hydrocarbons (e.g. chloro-benzenes, etc.), cycloalkanes, (e.g. cyclohexane, etc.). paraffins (e.g. petroleum or mineral oil fractions), chlorinated aliphatic hydrocarbons (e.g. methylene chloride, chloroethylenes, etc.), alcohols (e.g. methanol, ethanol, propanol, butanol, glycol, etc.) as well as ethers and esters thereof (e.g. glycol monomethyl ether, etc.), amines (e.g. ethanolamine, etc.), amides (e.g. dimethyl formamide etc.) sulfoxides (e.g. dimethyl sulfoxide, etc.), acetonitrile, ketones (e.g. acetone, methyl ethyl ketone, methyl isobutyl ketone, cyclohexanone, etc.), and/or water; as well as inert dispersible finely divided solid carriers such as ground natural minerals (e.g. kaolins, clays, vermiculite, alumina, silica, chalk, i.e. calcium carbonate, talc, attapulgite, montmorillonite, kieselguhr, etc.) and ground synthetic minerals (e.g. highly dispersed silicic acid, silicates, e.g. alkali silicates, etc.).

Surface-active agents, i.e., conventional carrier vehicle assistants, that may be employed with the present invention include, without limitation, emulsifying agents, such as non-ionic and/or anionic emulsifying agents (e.g. polyethylene oxide esters of fatty acids, polyethylene oxide ethers of fatty alcohols, alkyl sulfates, alkyl sulfonates, aryl sulfonates, albumin hydrolyzates, etc. and especially alkyl arylpolyglycol ethers, magnesium stearate, sodium oleate, etc.); and/or dispersing agents such as lignin, sulfite waste liquors, methyl cellulose, etc.

In the preparation of wettable powders, dust or granulated formulations, the active ingredient is dispersed in and on an appropriately divided carrier. In the formulation of the wettable powders the aforementioned dispersing agents as well as lignosulfonates can be included. Dusts are admixtures of the compositions with finely divided solids such as talc, attapulgite clay, kieselguhr, pyrophyllite, chalk, diatomaceous earth, vermiculite, calcium phosphates, calcium and magnesium carbonates, sulfur, flours, and other organic and inorganic solids which acts carriers for the pesticide. These finely divided solids preferably have an average particle size of less than about 50 microns. Granules may comprise porous or nonporous particles. The granule particles are relatively large, a diameter of about 400-2500 microns typically. The particles are either impregnated or coated with the inventive

pesticidal compositions from solution. Granules generally contain 0.05-15%, preferably 0.5-5%, active ingredient as the pesticidally-effective amount. Thus, the contemplated are formulations with solid carriers or diluents such as bentonite, fullers earth, ground natural minerals, such as kaolins, clays, talc, chalk, quartz, attapulgite, montmorillonite or diatomaceous earth, vermiculite, and ground synthetic minerals, such as highly-dispersed silicic acid, alumina and silicates, crushed and fractionated natural rocks such as calcite, marble, pumice, sepiolite and dolomite, as well as synthetic granules of inorganic and organic meals, and granules of organic materials such as sawdust, coconut shells, corn cobs and tobacco stalks. Adhesives, such as carboxymethyl cellulose, natural and synthetic polymers, (such as gum arabic, polyvinyl alcohol and polyvinyl acetate), and the like, may also be used in the formulations in the form of powders, granules or emulsifiable concentrations.

If desired, colorants such as inorganic pigments, for example, iron oxide, titanium oxide and Prussian Blue, and organic dyestuffs, such as alizarin dyestuffs, azo dyestuffs or metal phthalocyanine dyestuffs, and trace elements, such as salts of iron, manganese, boron, copper, cobalt, molybdenum and zinc may be used.

In commercial or agricultural applications, the present invention encompasses carrier composition mixtures in which the nematicidal compositions are present in an amount substantially between about 0.01-95% by weight, and preferably 0.5-90% by weight, of the mixture, whereas carrier composition mixtures suitable for direct application or field application generally contemplate those in which the active compound is present in an amount substantially between about 0.0001-10%, preferably 0.01-1%, by weight of the mixture. Thus, the present invention contemplates over-all formulations that comprise mixtures of a conventional dispersible carrier vehicle such as (1) a dispersible inert finely divided carrier solid, and/or (2) a dispersible carrier liquid such as an inert organic solvent and/or water, preferably including a surface-active effective amount of a carrier vehicle assistant, e.g. a surface-active agent, such as an emulsifying agent and/or a dispersing agent, and an amount of the active compound which is effective for the purpose in question

and which is generally between about 0.0001-95%, and preferably 0.01-95%, by weight of the mixture.

The nematicidal compositions can also be used in accordance with so-called ultra-low-volume process, i.e. by applying such compounds or by applying a liquid composition containing the same, via very effective atomizing equipment, in finely divided form, e.g. average particle diameter of from 50-100 microns, or even less, i.e. mist form, for example by airplane crop spraying techniques. Only up to at most about a few liters/hectare are needed. In this process it is possible to use highly concentrated liquid compositions with said liquid carrier vehicles containing from about 20 to 95% by weight of the nematicidal compositions or even the 100% active substances alone, e.g. about 20-100% by weight of the nematicidal compositions. The mixture of active materials may be applied, without limitation, in sufficient amounts so as to provide about 0.2 to 2 and preferably about 0.5 to 1.5 pounds of active materials per acre. Moreover, the required amount of the nematicidal composition contemplated herein may be applied per acre treated in from 1 to 200 gallons or more of liquid carrier and/or diluent or in from about 5 to 500 pounds of inert solid carrier and/or diluent. The concentration in the liquid concentrate will usually vary from about 10 to 95 percent by weight and in the solid formulations from about 0.5 to 90 percent by weight. Satisfactory sprays, dusts, or granules for general use contain from about 1/4 to 15 pounds of active nematicidal compositions per acre.

Furthermore, the present invention encompasses methods for killing, combating or controlling nematodes, which comprises applying to at least one of correspondingly (a) such nematodes and (b) the corresponding habitat thereof, i.e. the locus to be protected, e.g. to the soil for growing crops, to an area where a crop is to be grown, a correspondingly combative, a pesticidally effective amount, or toxic amount of the particular nematicidal compositions of the invention alone or together with a carrier as noted above. The instant formulations or compositions may be applied in any suitable usual manner, for instance by spraying, atomizing, vaporizing, scattering, dusting, watering, squirting, sprinkling, pouring, fumigating, and the like. The method for controlling nematodes comprises applying the inventive composition, ordinarily in a formulation of one of the aforementioned types, to a locus or area to

be protected from the nematodes, such as the foliage and/or the soil of plants. The compound, of course, is applied in an amount sufficient to effect the desired action. This dosage is dependent upon many factors, including the targeted pest, the carrier employed, the method and conditions of the application, whether the formulation is present at the locus in the form of an aerosol, or as a film, or as discrete particles, the thickness of film or size of particles, and the like. Proper consideration and resolution of these factors to provide the necessary dosage of the active compound at the locus to be protected are within the skill of those versed in the art. In general, however, the effective dosage of the compound of this invention at the locus to be protected-i.e., the dosage with which the pest comes in contact-is of the order of 0.001 to 0.5% based on the total weight of the formulation, though under some circumstances the effective concentration will be as little as 0.0001% or as much as 20%, on the same basis.

The nematicidal compositions and methods of the present invention are effective against a wide variety of nematodes and it will be understood that the nematodes exemplified and evaluated in the working Examples herein is representative of such a wider variety. For instance, the present invention can be used to control nematodes that attack plants. Representative crop plants that can be so treated include, without limitation, are cotton, corn, deciduous and citrus fruits, tomatoes, maize, ornamental plants, potatoes, rice, soybean, sugar beets, tobacco, wheat, etc.

The composition and method of the present invention will be further illustrated in the following, non-limiting Examples. The Examples are illustrative of various embodiments only and do not limit the claimed invention regarding the materials, conditions, weight ratios, process parameters and the like recited herein.

EXAMPLE 1

Nematicidal Effect of Plant Essential Oils

In vitro studies were conducted to determine the nematicidal activity of a mixture of eugenol, thymol, trans-anethole, α-terpineol and citronellal against the

root lesion nematode *Pratylenchus penetrans*. The mixture had the following ingredient ratios:

- Eugenol 10%
- Thymol 40%
- Trans-Anethole 25%
- α-Terpineol 10%
- Citronellal 15%

The bioassay was performed to determine the LC_{50}, or the lethal concentration for toxicity to 50% of the test population, of the plant essential oil mixture. The monoxenic *P. penetrans* colony with mixed life stages of nematodes were extracted from the media with fresh water two to three hours before being introduced into small BPI watch dishes (2 cm i.d.) with an additional 0.5 ml of the aqueous solution of the test sample added to each dish. There were seven final concentrations (27-135 ppm a.i.) and three replicates for each concentration. The watch dishes were then put in petri dishes (10 cm i.d.) and incubated at 23° C. The mortalities of the nematodes were calculated by counting dead and live nematodes under a microscope 24 hours post-treatment. Nematodes were considered dead if their bodies were stretched and immobilized even after prodding with a needle. The dead/immobilized nematodes were transferred to distilled water subjected to optimal conditions to regain mobility after the test to observe the reversibility of the nematicidal/nematostatic activity.

The LC_{50} for the test sample was 114 ppm a.i., compared to similar testing against the commercial product, oxamyl, against the same nematode (LC_{50} 250 ppm a.i.). Thus, plant essential oils are highly toxic on contact to nematodes at very low dosage rates compared to the commercial standards in the industry.

EXAMPLE 2

Nematicidal Effect of Plant Essential Oils Applied to Soil

Level two, pot test studies were conducted to determine the nematicidal activity of a plant essential oil, eugenol, based upon its ability to move through the soil and achieve the desired activity against root-knot nematodes. Field soil was

collected from a site known to be heavily infested with root-knot nematodes. The field site was used previously for tomato tests in two previous seasons. The soil was an Arrendondo fine sand with ca. 92% sand, 4% silt, and 4% clay, and < 1% organic matter. The amount of soil added to each 6-inch pot was ca. 1750 mls and 2,000 freshly hatched second-stage juveniles of *M. arenaria* race 1 were added by pipetting a 5 ml solution of the nematodes on to soil filled about half way of each pot. The remaining soil was added to the pots and they were placed at random on the bench inside a plant growth room. The soil in each pot was lightly moistened. Supplemental light was provided by 1,000 watt metal halide lamps, and heat generated by the lamps was removed by air conditioning.

After two days, the chemical treatments (eugenol, Nemacur 3EC, and Agri 50) were prepared and added to each pot. The chemicals were mixed at appropriate concentrations in 200 ml of water. A 500 ml syringe equipped with a 8002 teejet nozzle was used to spray all the chemicals, except Agri 50, in 20 ml of water over the surface of each pot. Agri 50 was added as a drench treatment. Following the application of the treatments, 300 ml of water was added to each pot to drench the chemicals down through the soil. The soil in each pot was kept moist by supplemental irrigation added every other day. After 5 days, a tomato (cultivar Rutgers) seedling was transplanted to each pot. Each treatment was replicated five times, except the untreated control with nematodes added. The untreated control was replicated 11 times.

One month later, the plants were removed, the roots washed free of soil, and observed for root-knot nematode galling. Galls induced by root-knot nematodes were counted, except when numbers were greater than 100. In this case the root system was indexed at 100. The timing for removing the root systems was based upon first detection of root galling. This precaution was taken to avoid recording galls induced by second generation root-knot nematodes juveniles.

The gall counts for eugenol treatments at 1,000 ppm (1,850 µl / 1,750 g soil) were equivalent to those of acceptable levels of the commercial standards. Lower levels of eugenol were not effective in providing acceptable control. Thus, plant essential oils can be effectively used to attack nematodes in the soil. Eugenol, in

particular, is at least as effective as the commercial standards in moving through the soil and providing adequate control. Eugenol is exempted from registration by the U.S. Environmental Protection Agency because it is a food grade material

As can be seen from the above discussion, the nematicidal combinations of active compounds according to the present invention are markedly superior to known pesticidal agents/active compounds conventionally used for nematode control in the agricultural and turf and ornamental markets. The pesticidal effectiveness of the particular new nematicidal combinations provides distinct safety benefits without sacrificing efficacy.

Although illustrative embodiments of the invention have been described in detail, it is to be understood that the present invention is not limited to those precise embodiments, and that various changes and modifications can be effected therein by one skilled in the art without departing from the scope and spirit of the invention as defined by the appended claims.

WHAT IS CLAIMED IS:

1. A nematicidal composition comprising, in admixture with an acceptable carrier if appropriate, a plant essential oil compound.

2. The nematicidal composition of claim 1, wherein the plant essential oil compound comprises a monocyclic, carbocyclic ring structure having six-members and substituted by at least one oxygenated or hydroxyl functional moiety.

3. The nematicidal composition of claim 1, wherein the plant essential oil compound is selected from the group consisting of aldehyde C16 (pure), amyl cinnamic aldehyde, amyl salicylate, anisic aldehyde, benzyl alcohol, benzyl acetate, cinnamaldehyde, cinnamic alcohol, α-terpineol, carvacrol, carveol, citral, citronellal, citronellol, p-cymene, diethyl phthalate, dimethyl salicylate, dipropylene glycol, eucalyptol (cineole) eugenol, iso-eugenol, galaxolide, geraniol, guaiacol, ionone, d-limonene, menthol, methyl anthranilate, methyl ionone, methyl salicylate, α-phellandrene, pennyroyal oil perillaldehyde, 1- or 2-phenyl ethyl alcohol, 1- or 2-phenyl ethyl propionate, piperonal, piperonyl acetate, piperonyl alcohol, D-pulegone, terpinen-4-ol, terpinyl acetate, 4-tert butylcyclohexyl acetate, thyme oil, thymol, metabolites of trans-anethole, vanillin, and ethyl vanillin.

4. The nematicidal composition of claim 1, further comprising a surface-active agent.

5. A method for controlling nematodes, which comprises applying to the locus where control is desired a pesticidally-effective amount of the composition of claim 1.

6. A nematicidal composition comprising, in admixture with an acceptable carrier if appropriate, a mixture of two or more plant essential oil compounds.

7. The nematicidal composition of claim 6, wherein each plant essential oil compound comprises a monocyclic, carbocyclic ring structure having six-members and substituted by at least one oxygenated or hydroxyl functional moiety.

8. The nematicidal composition of claim 6, wherein the plant essential oil compounds are selected from the group consisting of aldehyde C16 (pure), amyl cinnamic aldehyde, amyl salicylate, anisic aldehyde, benzyl alcohol, benzyl acetate, cinnamaldehyde, cinnamic alcohol, α-terpineol, carvacrol, carveol, citral, citronellal, citronellol, p-cymene, diethyl phthalate, dimethyl salicylate, dipropylene glycol,

eucalyptol (cineole) eugenol, iso-eugenol, galaxolide, geraniol, guaiacol, ionone, d-limonene, menthol, methyl anthranilate, methyl ionone, methyl salicylate, α-phellandrene, pennyroyal oil perillaldehyde, 1- or 2-phenyl ethyl alcohol, 1- or 2-phenyl ethyl propionate, piperonal, piperonyl acetate, piperonyl alcohol, D-pulegone, terpinen-4-ol, terpinyl acetate, 4-tert butylcyclohexyl acetate, thyme oil, thymol, metabolites of trans-anethole, vanillin, and ethyl vanillin.

9. A method for controlling nematodes, which comprises applying to the locus where control is desired a pesticidally-effective amount of the composition of claim 6.

10. A nematicidal composition comprising, in admixture with an acceptable carrier if appropriate, a mixture of one or more plant essential oil compounds in combination with a conventional pesticide, including nematicides.

11. The nematicidal composition of claim 10, wherein each plant essential oil compound comprises a monocyclic, carbocyclic ring structure having six-members and substituted by at least one oxygenated or hydroxyl functional moiety.

12. The nematicidal composition of claim 10, wherein the plant essential oil compounds are selected from the group consisting of aldehyde C16 (pure), amyl cinnamic aldehyde, amyl salicylate, anisic aldehyde, benzyl alcohol, benzyl acetate, cinnamaldehyde, cinnamic alcohol, α-terpineol, carvacrol, carveol, citral, citronellal, citronellol, p-cymene, diethyl phthalate, dimethyl salicylate, dipropylene glycol, eucalyptol (cineole) eugenol, iso-eugenol, galaxolide, geraniol, guaiacol, ionone, d-limonene, menthol, methyl anthranilate, methyl ionone, methyl salicylate, α-phellandrene, pennyroyal oil perillaldehyde, 1- or 2-phenyl ethyl alcohol, 1- or 2-phenyl ethyl propionate, piperonal, piperonyl acetate, piperonyl alcohol, D-pulegone, terpinen-4-ol, terpinyl acetate, 4-tert butylcyclohexyl acetate, thyme oil, thymol, metabolites of trans-anethole, vanillin, and ethyl vanillin.

13. The nematicidal composition of claim 10, wherein the conventional pesticide is a nematicide selected from the group consisting of methyl bromide, oxamyl, Nemacur 3, and Agri Mek.

14. A pesticidal composition to offer multiple pesticidal benefits comprising, in admixture with an acceptable carrier if appropriate, a mixture of one or more plant essential oil compounds.

15. The pesticidal composition of claim 14, wherein each plant essential oil compound comprises a monocyclic, carbocyclic ring structure having six-members and substituted by at least one oxygenated or hydroxyl functional moiety.

16. The pesticidal composition of claim 14, wherein the plant essential oil compounds are selected from the group consisting of aldehyde C16 (pure), amyl cinnamic aldehyde, amyl salicylate, anisic aldehyde, benzyl alcohol, benzyl acetate, cinnamaldehyde, cinnamic alcohol, α-terpineol, carvacrol, carveol, citral, citronellal, citronellol, p-cymene, diethyl phthalate, dimethyl salicylate, dipropylene glycol, eucalyptol (cineole) eugenol, iso-eugenol, galaxolide, geraniol, guaiacol, ionone, d-limonene, menthol, methyl anthranilate, methyl ionone, methyl salicylate, α-phellandrene, pennyroyal oil perillaldehyde, 1- or 2-phenyl ethyl alcohol, 1- or 2-phenyl ethyl propionate, piperonal, piperonyl acetate, piperonyl alcohol, D-pulegone, terpinen-4-ol, terpinyl acetate, 4-tert butylcyclohexyl acetate, thyme oil, thymol, metabolites of trans-anethole, vanillin, and ethyl vanillin.

INTERNATIONAL SEARCH REPORT

Inter onal Application No
PCT/US 00/06115

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A01N65/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
E	WO 00 21364 A (YEGEN OKTAY ;TUZUN SADIK (US); UNIV AUBURN (US)) 20 April 2000 (2000-04-20) the whole document ---	1-16
X	DATABASE WPI Week 197751 Derwent Publications Ltd., London, GB; AN 1977-91382Y XP002137933 & JP 50 094118 A (HIKARU KOGYO KK), 24 December 1973 (1973-12-24) abstract --- -/--	1-12, 14-16

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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Date of the actual completion of the international search	Date of mailing of the international search report
17 May 2000	06/06/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Bertrand, F

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X	CHATTERJEE A ET AL: "nematocidal principles from 2 species of lamiaceae" JOURNAL OF NEMATOLOGY, vol. 14, no. 1, January 1982 (1982-01), pages 118-120, XP000886945 the whole document	1-12, 14-16
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X	STADLER MARC: "fatty acids and other compounds with nematicidal activity from cultures of basidiomycetes" PLANTA MEDICA, vol. 60, no. 2, April 1994 (1994-04), pages 128-132, XP000886922 the whole document	1-9
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X	SANGWAN N K ET AL: "nematicidal activity of essential oils of cymbopogon grasses" NEMATOLOGICA, vol. 31, 1985, pages 93-99, XP000886954 the whole document	1-12, 14-16
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Information on patent family members

Inter onal Application No
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JP 55064736 A	15-05-1980	NONE	